File with Instruction Manuals. Z-4

INSTRUCTION MANUAL

Model Z-41

NJE CORPORATION

345 CARNEGIE AVENUE, KENILWORTH, N. J.

N J E CORPORATION

INSTRUCTION, MAINTENANCE AND REPAIR MANUAL

FOR MODEL Z-41

N J E CORPORATION
345 Carnegie Avenue
Kenilworth, New Jersey

SECTION I

SPECIFICATIONS AND GENERAL DESCRIPTION

MODEL ET-41
or
MODEL Z-41

Input: 105-125 volts, 60 cycles per second, single phase, at approximately 12 amperes, 70% power factor, at full load.

Output: Continuously variable by front panel control from 32 to 80 volts DC at 0 to 10 amperes.

Ripple: 1% RMS maximum.

Regulation: Line, less than 0.5% for line voltage variations of 10%.

Load, less than 1%, no load to full load.

Recovery Time: Less than 75 milliseconds from ± 10% line or ± 50% load transients. (ET-series).
Zero for line transients of ± 10% or load transients of ± 25%. (Z-series).

UNPACKING AND INSTALLATION

The complete power supply shipment consists of a small carton containing the thyratron tubes, and a large carton or crate containing the power supply. Both containers should be opened immediately upon receipt, and the contents inspected for shipping damage. When the unit leaves the factory it is thoroughly checked, both electrically and mechanically, and is warranted to be in perfect operating condition. However, we cannot guarantee that no damage will be incurred during shipment. Any evidence of mishandling, such as broken, deformed, or missing parts, should be brought to the attention of the shipping agency immediately, and a claim should be entered. Open the cabinet doors and inspect all components and wiring, both on the chassis and panel, as well as the mechanical condition of the housing.

After the unit has been placed in its operating location, unwrap the tube anode caps (inside the cabinet) and untie their leads. Then install the tubes in their clamps or sockets. Note that the tube, anode cap, and socket must be properly matched. Each set is identified by a small red letter, and it is extremely important for proper operation that the tubes be installed and connected in accordance with the letter code.

All connections are made at the terminal strip at the rear of the chassis. The AC input line is to be connected to the "AC" terminals at the left end of the strip. The output of the supply can be connected for either polarity, and can be floated as much as 500 volts (peak) above or below chassis ground. However, the most stable operation will be obtained when one of the two output terminals ("POS or "NEG") is connected to the chassis ground terminal (GND) either by a jumper, or through a 0.1 microfarad [illegible] capacitor.

To permit monitoring and regulating the load voltage without introducing an error due to the voltage drop in the interconnecting cables to the load, the input terminals of the correction amplifier have been brought out to the rear terminal strip ("POS SEN" and "NEG SEN"). These terminals must be connected through a separate "sensing" lead directly to the load terminals, observing the proper polarity. A 20-gauge stranded, shielded, insulated wire is recommended. (External insulation is required to permit connection for either polarity). While it is possible to jumper the sensing terminals directly to the "POS"and "NEG" output terminals at the terminal strip, this connection causes the load cables to be included as part of the external load, and the actual voltage at the remote load terminals will vary accordingly with changes in load current.

IMPORTANT: To avoid the possibility of damage in the event that the unit is put into use before these instructions are read, the sensing terminals are jumpered to the output terminals at the rear terminal strip prior to shipment from the factory. The jumper wires should be removed, and sensing leads should be connected to the load as indicated above, to obtain maximum stability of the load voltage.

Operating procedure is as follows:

1. Place AC and DC switches in OFF position
2. Connect AC line to "AC" input terminals at rear of chassis.
3. Connect load terminals to "POS"and "NEG" output terminals, using insulated cables of appropriate gauge.
4. Connect a jumper from chassis ground terminal (GND) to "POS" or "NEG" output terminal as required for proper load polarity. If load is to be floating, use a 0.1 mfd 600-volt capacitor instead of a jumper.
5. Connect sensing leads from "POS SENS" terminal to positive load terminal and from "NEG SENS" terminal to negative load terminal.
6. Throw AC switch to ON position.
7. Set output voltage control to maximum counterclockwise (minimum output) position.
8. When TIME DELAY OVER pilot lamp lights, throw DC switch to ON position.
9. Adjust the output voltage control to provide the required load voltage.

Theory of Operation

Power Distribution

Since the AC - 2 line of power supplies contains a wide range of input voltages and output currents, circuit details will vary among the various models. A single-phase full-wave rectifier circuit is used in models rated at 400 watts or less, but higher output powers may require the use of three-phase input power, with a three-phase full-wave or full-wave bridge rectifier circuit. Essentially all high power switching supplies use basic circuit and connection principles that are the same for all models. (Refer to the schematic diagram at the back of the manual.)

When primary power from the AC line is applied to the input terminals of the supply, and the AC power switch S1 is closed, the primary of the transformer rectifiers and rectifier tubes are energized immediately, and plate voltage is applied to the conversion amplifier. Since the thyratrons are gas filled tubes, they are subject to damage if plate power is applied at times before their filaments reach operating temperature. To eliminate this possibility, a two minute automatic time-delay relay K1 is employed to prevent application of power to the primary of the main power transformer during the warm-up period. When this relay closes its contacts, an amber pilot lamp on the front panel lights, indicating that the supply is ready to furnish DC power to the load. If the DC power switch S2 is then closed, the coil of the primary contactor K2 is energized, in turn closing the primary circuit of the main power transformer, enabling the thyratrons to conduct current (through the anode-timer TD timer) to the external load. Incidentally (in regarding the grid control circuits, the thyratrons can be considered as self-saturable gas diodes which control the DC output voltage of the transformer

secondary. The combined rectified output of the [illegible] is smoothed and filtered by the choke-input filter L2-C1, and delivered to the remote load through an external cable connected to the [illegible] output terminals.

To permit adjustment of the output voltage, and to maintain a means of automatically maintaining the voltage at the selected value despite line and load variations, a grid-control circuit is provided for each tube, and all control circuits are operated by the output of a common correction amplifier circuit.

GRID CONTROL CIRCUIT:

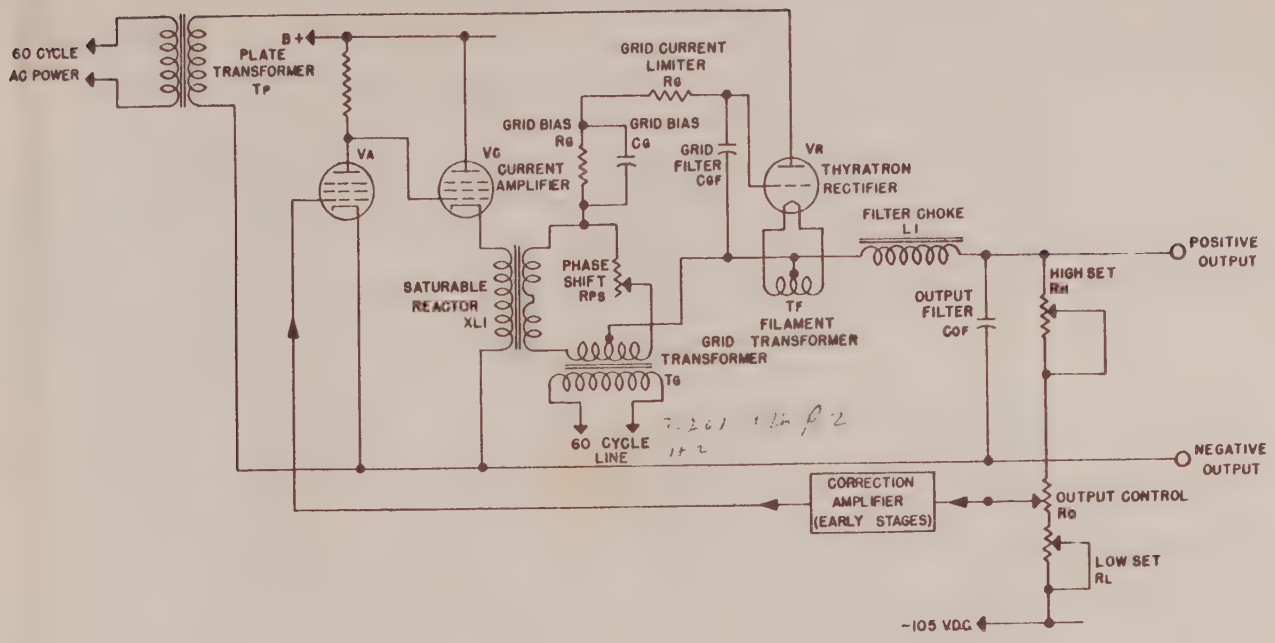
The action of the grid control circuit is illustrated in Figure 1. The principle of [illegible] is used in the [illegible] in which [illegible] the secondary of TG is a phase-shifting circuit consisting of variable resistor RPS and saturable (variable) reactor XL1.

The output of this phase-shift circuit is taken from the [illegible] and the [illegible] of T2 and T3, and consists of a small alternating voltage whose phase with respect to that of plate voltage [illegible] the ratio of RPS and XL1. The parallel combination of resistor R3 and capacitor C3 is [illegible] a DC reference bias is [illegible] is superimposed upon this DC bias.

For any given value of plate voltage on the tube, there is a certain [illegible] value of negative grid voltage which will just prevent the

thyratron from conducting. This value is known as the critical grid voltage, and is shown as a dotted curve in B of Figure 1 for the negative portion half-cycle of plate voltage. Until the grid voltage becomes less negative than the referenced critical value at any point in the positive half-cycle, the tube will fire at that instant and conduct throughout the remainder of the positive-plate-voltage interval..

Ignoring the effects of the AC signal, the DC (grid rectification) bias holds the grid sufficiently negative to maintain the tube in a continually cut off condition. When the AC signal voltage is superimposed on this DC bias, the resultant plus fluctuating value may raise the control DC value, as shown in figure D. At some point during the positive half-cycle of plate voltage, the voltage on the grid becomes less negative than the critical grid value at that point, and the tube fires. This instant is indicated at 1. Since the positive going bias voltage varies inversely the critical grid voltage curve. The tube conducts current throughout the remainder of the half-cycle, and is extinguished when the plate voltage drops to zero. By shifting the place of the AC grid control wave (with respect to the plate voltage wave), the instant of firing can be changed to a point earlier or later in the cycle, causing the tube to conduct during a greater or lesser fraction of the half-cycle. Figure D shows the AC grid control wave intersecting the critical grid voltage wave at an earlier point in the plate voltage half-cycle (point 2). Inspection of figures C and D shows that shifting the AC grid control wave to the right decreases the conducting angle (interval of conduction) of the tube. The


60 CYCLE
AC POWER
PLATE
TRANSFORMER
TP
B+
VA
VG
CURRENT
AMPLIFIER
GRID BIAS
RG
GRID BIAS
CG
GRID CURRENT
LIMITER
RG
GRID
FILTER
CGF
VR
THYRATRON
RECTIFIER
FILTER CHOKE
LI
POSITIVE
OUTPUT
HIGH SET
RH
OUTPUT
FILTER
COF
PHASE
SHIFT
RPS
SATURABLE
REACTOR
XLI
TF
FILAMENT
TRANSFORMER
GRID
TRANSFORMER
TG
60 CYCLE
LINE
NEGATIVE
OUTPUT
CORRECTION
AMPLIFIER
(EARLY STAGES)
OUTPUT CONTROL
RO
LOW SET
RL
-105 VDC

A.

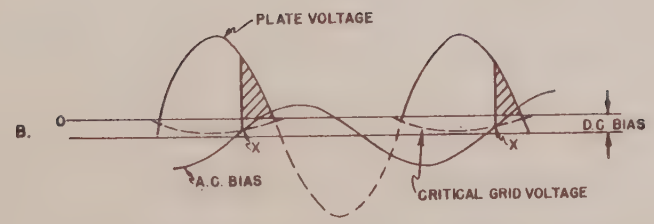


PLATE VOLTAGE
B.
0
X
X
D.C. BIAS
A.C. BIAS
CRITICAL GRID VOLTAGE

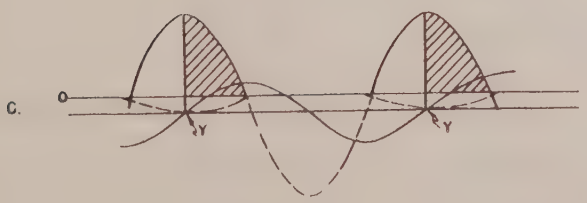

C.
0
Y
Y

FIG. 1

shaded areas of the plate waves indicate the period during which the tube conducts, and are representative of the relative amount of power furnished to the load in each case.

It is apparent from the diagrams that the greater the lag of the grid wave with respect to the plate wave, the smaller will be the conduction angle. This principle is used to automatically control the load voltage in the following manner (refer to Figure 1A).

The voltage drop across the external load is connected (through a pair of external sensing leads) across a voltage divider RH-RO-RL. The input to the correction amplifier is determined by the setting of the movable arm of a potentiometer, RO which forms a part of the voltage divider. The grid potential of VA, the final stage of the correction amplifier, [illegible] plate of VA is direct-coupled to the control grid of VC. The cathode [illegible] as the reference grid control circuit. Since the potentiometer RO [illegible] the control winding of saturable reactor [illegible] the control winding of SR [illegible] the control winding of SR [illegible] the control winding of SR

stabilizing positive charge to the cathode, an equilibrium is established at a particular value of output voltage.

When the load resistance decreases, the output voltage at the supply tends to decrease because of the greater current drain. This causes the control grid of the amplifier to be less negative, or more increasing the current flowing by making the control grid of the thyratron less negative. This increases the grid bias on the thyratron to grid bias so as to cause the tube to conduct for a greater portion of the positive half-cycle of plate voltage. The increased charging period compensates for the increased drain on the supply and the output voltage tends to remain essentially constant. A decrease in the output voltage is counteracted by a similar action by a decrease in the tube conduction interval.

Regulator theory says that, if the compensating action results only from the "error" detected by monitoring the output, the compensation can never be complete, regardless of the error amplifier gain. The equilibrium system is a closed loop, since an input voltage change produces an output voltage change, which in turn is fed back to the input to cause a way as to counteract the original change in the input. Should the "error" be reduced to zero, the compensation would likewise disappear. This would imply that an absolutely steady output can be maintained with no compensation, which is obviously untrue. Increases in the gain of the correction amplifier permit it to achieve equilibrium with less residual error, but a small error must always remain, in a true proportional regulator.

While the foregoing material outlines the functioning of a single thyratron rectifier, it can be applied without change to any one of the six rectifiers in the single-phase units, the three rectifiers in the three-phase half-wave units, or the [illegible] rectifiers in the six-phase units. The plate and grid [illegible] so that each rectifier conducts in its turn, and the repetitive sequence of current pulses is smoothed and filtered by the common choke-input filter at the output of the supply. The correction amplifier in the supply simultaneously controls the degree of phase shift of the A6 grid voltage [illegible] in proper sequence to control all phases of the output.

[illegible] the relative values of the A1 [illegible] as to control the output voltage of an [illegible] rectifier tubes, and thereby [illegible] at least two [illegible] equal spacing of the [illegible] as to coincide with the rated output voltage range.

[illegible] the A6 [illegible] rectifier V-101 and a [illegible] a six-rectifier V102 establishes a negative [illegible] by the tube V-104. The tube V103 provides a [illegible] parameter potential for the [illegible]

are replaced.

PREVENTIVE MAINTENANCE:

To establish a preventive maintenance program, it is essential that the equipment be tested properly after it is first taken operable for the first time, when it is most likely to be in good operating condition, and that the results of these tests be recorded as a reference for comparison with subsequent periodic tests. By keeping a running log of periodic results, it will be possible to detect not only radical changes in operating characteristics, pointing to imminent failure of the equipment due to a defective component, but also the slow deterioration in performance which is a natural result of component aging.

A set of standard operating conditions should be selected, and for each test these conditions should be carefully set operationally, under these conditions. For a radio test, a pre-determined load should be connected across the output terminals of the supply, and the unit adjusted for a selected output voltage across the load. A thorough check of the equipment should then be made with regard to ripple and general voltage stability, including the most periodic fluctuations and random erratic variations. A dynamic test should then be made by observing the output voltage on an oscilloscope as the pre-determined load is connected and disconnected, recording the effect, and noting the regulation. Having the above tests on a regular preventive or semi-monthly basis, and recording the results in log form, will help to keep shutdown and corrective to a minimum.

A visual check of the unit should also be made at the time that these

operational tests are completed. Look for evidence of deterioration, such as discoloration, melted or burned insulation, corroded terminals, uneven glow in the rectifier tubes, blown rectifier fuses. Shut down the unit and then with soft cloth remove accumulations of dust or lint, smoke soot, dirt, and other foreign material that have accumulated in the equipment.

CAUTION: ALWAYS shut down the equipment before cleaning it or touching it internally for any reason!

Vacuum tubes should be tested every 1000 hours, and replaced at the first sign of deterioration. It is recommended that all tubes then be replaced automatically after each 2,500 hours of operation. Experience with a manufacturer's warranty for good hours of operation, and scheduled replacement of these tubes at the end of this period is warranted. This coincides with the advisability of recording equipment hours of operation in the log at yearly intervals, or sooner if the operating schedule is erratic.

After every 10,000 hour period of operation, the equipment should be thoroughly overhauled. All panels should be disconnected, and all components, wiring, and connections should be closely inspected, including; potentiometers, relays, and other mechanical items should be checked for looseness, sticking, binding, pitting, poor workers, or evidence of malfunction. The cabinet interior, panels, and individual components should be thoroughly vacuum cleaned before reassembly of the equipment. All traces of rust or corrosion should be removed, and the surface painted or varnished as required.

indicate that the equipment is not regulating properly, a check of the control circuits, filter choke, and transformers, in that order.

Observation of the input voltage to the filter, by means of an oscilloscope if possible, will be the most rapid means of isolating the defective component. Check for irregularity in this voltage, and try replacement of the thyratrons as a means of eliminating the irregularity.

fuses, or failure of any of the components mentioned above. Again, an

the input to the filter.

1. Single-Phase Units

phase-shift network must be adjusted so that the DC output voltage of the supply will swing from below minimum to above maximum rated output, at any load within its rating, as the control amplifier is swung through its full range. The network is designed so that an increase in current through the control winding of the saturable reactor [illegible] will advance the phase of the thyratron AC grid voltage, thereby causing the DC output voltage to increase. Obviously, an increase in the value of the resistance in R201 will advance the phase and raise the output voltage. Calibration of the network is accomplished as follows:

a. Remove the current amplifier tube V108 (type 6AM5) from its socket. This causes the current in the control winding of the saturable reactor to drop to zero.

b. Adjust phase-shift resistor R201 to a value which gives slightly less than minimum rated DC output voltage, with no external load connected to the supply, and the less voltage at the highest rated value.

c. Insert V108 in its socket, and connect a jumper between its grid and cathode. This will saturate the tube, drawing maximum current through the control winding of the saturable reactor. This should raise the output voltage well above the rated maximum. If it does not, a defective

component or connection is indicated. After making the check, remove the grid-cathode jumper from V108.

d. Rotate the OUTPUT control R1 to its full clockwise position, and adjust the HIGH SET control R2 to produce a DC output voltage somewhat above the rated maximum. Connect an external load of a value sufficient to draw the maximum rated output current, and readjust R118 to provide a load voltage somewhat slightly higher than the rated maximum. (Note: If the load is to be located at a considerable distance from the supply, the maximum output voltage should be set high enough to allow for the expected voltage drop in the interconnecting cable.)

e. Disconnect the external load, and rotate the OUTPUT control to its maximum counterclockwise position. Adjust the LOW SET Control R3 so as to produce a DC output voltage slightly [illegible] value. If this is not attainable, adjust the phase-shift resistor R201 to permit reaching the required output value with R3.

f. [illegible] R1 still provides greater than maximum rated output at full clockwise position, at full load, with line voltage at the lowest rated value.

2. Three-Phase Units

[illegible]

is controlled through a separate phase-shift circuit. In units employing six phase half-wave rectification each pair of thyratrons is controlled by a single phase-shift circuit. In units employing six phase half-wave rectification, each pair of thyratrons is controlled by a single phase-shift circuit whose output is transformer-coupled to the two thyratron grids in push-pull. In both cases, all phase shift circuits are controlled by one common correction amplifier.

Adjustment of the phase shift network is identical to that outlined above for single-phase units, except that equal adjustments must be made on all three phase shift resistors. This is easily accomplished by connecting an oscilloscope from the load terminal of filter choke L1 to the negative output terminal, and adjusting for zero-to-zero at least six half-wave loops of the rectified output. By connecting the patching cords adjusting the three phase-shift resistors, equal amplitudes can be obtained for the outputs from the individual transformers, to assure equal sharing of the load. This adjustment should always be made as a final check after the readjustment of the phase-shift circuits.

3. Oscillation Suppressor Circuit Adjustment.

Capacitors C108, 109, C105 and resistors R108, and R116 constitute a frequency and phase-shift compensating [illegible] coming positive and causing the system to break into oscillation. While this type of oscillation is not inevitable, it is encountered frequently enough to warrant inclusion of the compensating circuit as a standard item. Should the power supply exhibit a tendency to oscillate, after maintenance adjustments or a tube replacement, adjust potentiometer R116 to a position which causes the oscillation to disappear.

NOTE: —— DESIGNATES #20 WIRE
—— DESIGNATES #20 SHIELDED WIRE

"OFF" "ON" S1 "AC" — K1 TIMER — "TIME DELAY OVER" — "OFF" "ON" S2 "DC"
I1 GREEN — I2 AMBER — I3 RED

P1 MATES WITH S1 (AMPLIFIER - SEE DWG. NO. S-AMPI-ET)

R2 100K 2W "OUTPUT VOLTAGE CONTROL" — HI-SET
R1 50K 2W — C.W.
R3 100K 2W — LO-SET
M1 "OUTPUT VOLTAGE"

CONTROL PANEL

M1,2 SUPPLIED IN "M" DESIGNATED MODELS ONLY.
"OUTPUT CURRENT" M2

POS. OUTPUT
GROUND
NEG. OUTPUT
POS. SENSING
POS. OUTPUT
GROUND
NEG. OUTPUT
NEG. SENSING

P2 — GC1

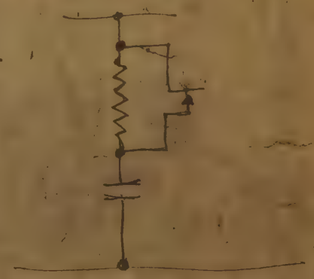
T1/F2 — #10 A, #10 B
VIB — .001 MFD. 600V C4
VIA — C3 .001MFD. 600V
Vib = 6.3 V
Via = 6.3 V

MATES WITH S102 (AMPLIFIER - SEE DWG. NO. S-AMPI-ET)

F4 5A
TB2
K2
T1
F1 30A
115 V. 60 ~ INPUT

F2 20A
L1 — #L1-ET41
L2 — #L2-ET41
15A F3 — F3 FUSE PER BANK — 15A F3
50Ω 100W.
C1 2250 MFD @125V 5 IN PARALLEL
C2 2250 MFD @125V 40 IN PARALLEL
330Ω
R4A,B 200Ω-50W 2 IN PARALLEL

NOTE: —— DESIGNATES #12 WIRE —— DESIGNATES #20 WIRE } UNLESS OTHERWISE SPECIFIED



MATERIAL TYPE:	GRID CONTROLLED RECT.
FINISH	
CIRCUIT:	1Ø, FULL WAVE
DRAWN	DRE 2-11-56
	N. J. ELECTRONICS CORP.
	CONTROL PANEL & RECTIFIER CIRCUIT SCHEMATIC
DWG. NO.	241
SHEET	4
SHEETS	

T101
HJE
ETORET

YELLOW
YELLOW
RED 6
BLK
BLK
GRID
32V.
GRN.
DRANGE

V101
6X4

V102
6X4

C101
20 MFD
450V

C102
20 MFD
450V

R101
NN
3K 10W

R102
NN
7.5K 10W

V103
CA2

5,1
150
2,4,7

R103
200K 1W

C107
1000 MMF
500V

V107
6U8

VR

R109
1M 1W

R110
150K
1W

R111
150K
1W

V108
6HQ5

VC

AB

C110
.05 MFD
200V
CDMP255

R112
3M 1W

C111
.05 MFD
200V
CDMP255

R113
3M 1W

R104
200K
1W

C106
.25
MFD
200V
CDMP225

R107
10K
1W

R114
1M ½W

R115
1M ½W

V104
CA2

5,1
2,4,7

-150

R116
5M 2W

C109
CDMP225
.25 MFD.
200V

V106
12A

R105
1M
2W
-85V

R106
100K 1W

Sync Amp

Comparison Amp

V105
6SA2

5,1
2,4,7

C105
.05 MFD
200V
CDMP235

SEE NOTE 2

C108
.1 MFD 400V
MPAPI

R108
100K ½W

#20

J101

MATES WITH P1 (CONTROL PANEL)

J102

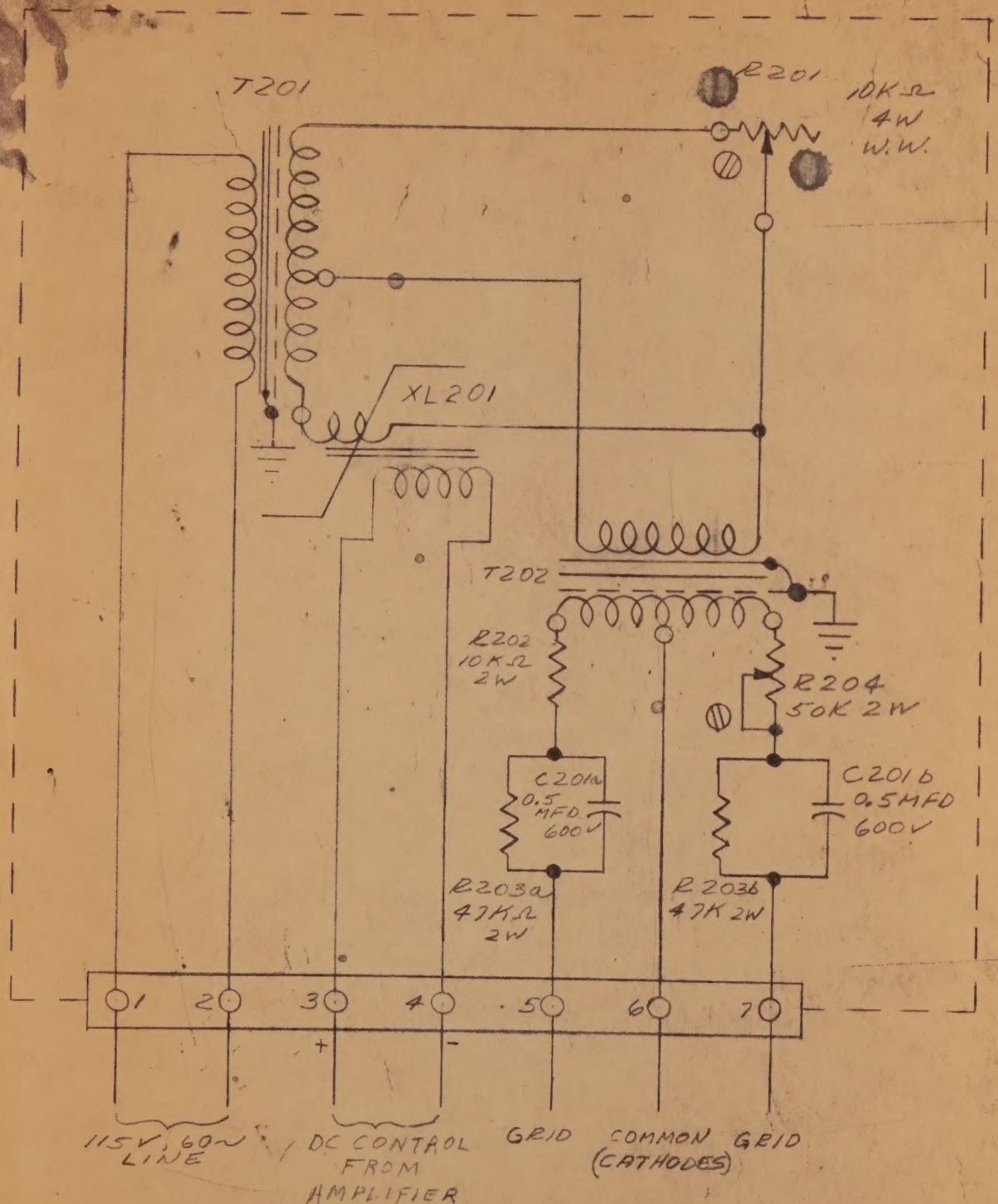
MATES WITH P2
(TUBE SHELF)

NOTES- 1-USE #20 WIRE FOR FILAMENTS
USE #24 WIRE FOR ALL OTHER WIRING
UNLESS OTHERWISE SPECIFIED.
2-1UF, 400V CAPACITOR USED ON MODELS 2-41-CM, 2-52-CM, 231-RM

FOR ASSEMBLY SEE A-AMPI-ET

MATERIAL		N. J. ELECTRONICS CORP.
FINISH		845 CARNEGIE AVE. KENILWORTH, N. J.
ALL DIMENSIONS IN INCHES	UNLESS OTHERWISE SPECIFIED	STANDARD ET AMPLIFIER SCHEMATIC (FOR VOLTAGE REGULATORS)
DECIMALS ± .010		
FRACTIONS ± 1/64		
ANGLES ± 1°		
DESIGNED	APPROVED BY	DWG. NO. S-AMPI-ET
DRAWN BY J.J.G	CHECKED	SHEET OF SHEETS
DATE 5-9-56	SCALE FULL	

GC-ET/1


T201
R201
10K Ω
4W
W.W.
XL201
T202
R202
10K Ω
2W
R204
50K 2W
C201a
0.5
MFD.
600V
C201b
0.5MFD
600V
R203a
47K Ω
2W
R203b
47K 2W
1
2
3
4
5
6
7
+
-
115V, 60~
LINE
DC CONTROL
FROM
AMPLIFIER
GRID
COMMON GRID
(CATHODES)

MPONENTS - MANUFACTURED BY N.J.E.	
201	GRID-XFR, N.J.E. # T201-ET
202	COUPLING - XFR, N.J.E. # T202-ET
201	GRID CONTROL REACTOR N.J.E. # XL201-ET

TE:
S GRID CONTROL CIRCUIT APPLIES
1Ø FULL WAVE (1 REQ'D) AND FOR 3Ø
L WAVE (3 REQ'D)

N. J. ELECTRONICS CORP.
349 CENTRE AVE. JERSEY CITY N. J.

THYRATRON GRID
CONTROL CIRCUIT
N.J.E. MOD. # GC-ET/1

DRI
6-26-56

ST-GC ET/1

SHEETS

OUR WARRANTY: N J E Corp. warrants each power supply manufactured by them to be free from defects in material and workmanship. Our liability under this warranty is limited to servicing or adjusting any instrument returned to the factory for that purpose and to replacing any defective parts thereof, except tubes and fuses in "standard-grade" models. This warranty is effective for one year after delivery to the original purchaser when the instrument is returned, transportation charges prepaid by the original purchaser, and which upon our examination is disclosed to our satisfaction to be defective. If the fault has been caused by misuse or abnormal conditions of operation, repairs will be billed at cost. In this case, an estimate will be submitted before the work is started.